

XIV. NOTES FROM THE BENGAL FISHERIES
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EMBRYOLOGICAL AND DEVELOPMENTAL STUDIES OF
INDIAN FISHES.

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(With Plates XVI—XIX.)

This paper consists of four parts; part one deals with two new species of Leptocephalids found in the brackish waters of the Gangetic Delta; in part two we have described the life-history of an Indian Teleost—*Notopterus chitala*; the third part is a description of the egg-capsule of an Indian dogfish, and the fourth consists of descriptions of intra-uterine embryos of some Indian sharks and rays, together with a discussion of various points of general zoological interest resulting from this study.

I. LEPTOCEPHALIDS.

On the occasion of a visit, by one of us, to the Sunderbans, during March 1918, well preserved specimens of two species of Leptocephalids were obtained.

Leptocephalus milnei, sp. nov.

(Pl. XVI, fig. 1.)

This species has the usual band-like form.

Description.—Number of segments in a specimen, 120.

Length 55.4 mm.; height 8.3 mm.; head 4 mm.; distance of anus from the end of the tail, 13.2 mm.; eye 1.1 mm.; snout 1.3 mm.; post temporal part of the head 1.6 mm.; height 6.7 mm.; head 13.8 mm.; tail 4.2 times in total length. Snout rounded, head portion posterior to it slightly convex. Eye 3.6 times in the head, slightly smaller than the snout and about one and a half times in the post temporal part of the head. Gape of the mouth extending behind the eye.

Anus below 79th segment, three times farther from the tip of the snout than from the tail. Very minute teeth are present on the lower and the upper jaws.

Pectorals very small, rounded. Dorsal and anal fins with a large number of fin-rays, three to each myosegment.

There is a minute pigment spot at the base of each of the dorsal, caudal, and anal fin-rays, otherwise the animals preserved in spirit are of a creamy colour. When alive they were quite pellucid, but could just be distinguished swimming in the muddy water.

Specimens obtained in a small beam-trawl at Doorakara, Sunderbans (Gangetic Delta), Bengal, on 15th and 16th of March 1918.

Type-specimens registered in the collection of the Zoological Survey of India, No. F⁹⁷⁴⁸.

We have much pleasure in naming this species in honour of Mr. Milne, M.A., I.C.S., Director of Agriculture, Bihar and Orissa, in recognition of much assistance rendered to the Fisheries Department.

Leptocephalus vermicularis, sp. nov.

(Pl. XVI, figs. 2, 3.)

This species, instead of having the usual band-like form, is rounded like a worm.

Description.—Number of segments in a specimen, 122.

Length 61.2 mm.; height 4.1 mm.; head 4.3 mm.; distance of anus from the end of the tail, 37.8 mm.; eye .6 mm.; snout 1.1 mm.; post temporal part of the head 1.8 mm. Height 14.9, head 14.2, tail 1.6 times in total length. Snout acutely rounded, leading gradually to the post temporal portion which is very broad, even more so than the body. Eye 7.2 times in the head, about half the size of the snout and three times in the post temporal portion of the head.

Gape of the mouth extends a little behind the eye. Anus below the 47th segment, its distance from the tip of the tail being one and a half times the distance from the snout. Minute teeth on the upper jaw, none on the lower. Small rounded pectoral fins. The dorsal, caudal and anal fins rather small, with a large number of fin-rays, three to each myosegment.

There is a minute black spot at the base of each fin-ray, and a large number of scattered pigment spots, specially collected in groups on the ventral surface of the body. These pigment spots are visible only when specimens are examined under a high magnification, otherwise the specimens appear of a creamy colour when preserved. When alive they were quite pellucid and wriggled very quickly in the muddy water.

Only two specimens were obtained along with those of the other species described above, in a small beam-trawl at Doorakara, Sunderbans, Gangetic Delta, Bengal, on the 15th and 16th of March 1918.

Type-specimens registered in the collection of the Zoological Survey of India, No. F⁹⁷⁴⁹.

II. LIFE-HISTORY OF *NOTOPTERUS CHITALA* (Ham. Buch.).

(Pl. XVI, figs. 4-10.)

During the months of June and July 1915, Mr. S. M. Mohsin, Superintendent of Fisheries, found eggs of *Notopterus chitala* attached to the masonry work of a bathing ghat on the banks of the river Ganges at Buxar, Bihar. He made a few observations on the nature of the nest, the guarding of the nest by the parent fish and the manner in which the eggs are deposited. Mr. Mohsin collected eggs from the first nest and from other nests which were subsequently found in the vicinity. He also hatched a few eggs in a large earthenware vessel and thus obtained specimens of some of the later larval stages. Our account is based on the material collected by Mr. Mohsin. This material, besides being far from complete, is in a very poor state of preservation. The exact age of the specimens is not stated and cannot now be ascertained. As, however, nothing is known about the life-history of this, or of any of the nearly related forms, we have thought it advisable to give the following description even though it is very incomplete. Field notes from Mr. Mohsin's report on the subject are also incorporated, but it should be understood that we have, as yet, had no opportunity of verifying or extending his investigations.

Breeding habits.—As a result of his observations and local enquiries Mr. Mohsin arrived at the conclusion that the spawning season of this fish extends from the end of May to the middle of July. This statement must, however, be taken with a certain amount of reservation as we know from experience that the information supplied by fishermen is generally inaccurate, and Mr. Mohsin's observations were of too limited a character to have enabled him to arrive at a very definite conclusion.

This species prefers to deposit its eggs on solid substances (such as brick-walls, stones, masonry, etc.) close to the banks of the river. The female, when shedding eggs, lies close to the object on which they are to be deposited, the body of the fish being inclined at a certain angle to the vertical. The eggs, being glutinous, adhere firmly to the object on which they are deposited. The male, later on, emits the milt over them. This very simple type of nest was the only one observed in this case. Usually, from three to five hundred eggs are laid at a time. During the period of laying and hatching, the nest is very carefully guarded by the parent fish and any intrusion is vigorously resented, fishermen attempting to go near the nest are frequently bitten. Unfortunately, no observations were made as to whether both the male and the female fish guard the eggs, or whether it is done by one of the parent fishes, or by both together, or alternately. Further, nothing is known as to whether parental care extends to the fry stages or not. According to Mr. Mohsin the eggs hatch out in about two weeks. When hatched, the fry have a large yolk-sac, and, during the four to five days

which elapse before this is absorbed, the fry lie quiet and idle, and do not swim unless disturbed.

The following stages were present in the collection :—

- (i) Stages with the embryos still enclosed in large globular eggs (figs. 4-6).
- (ii) Embryos hatching out, some having the egg membrane still attached.
- (iii) Stages with the embryos having the yolk-sac in various stages of absorption (figs. 7-10).

The following descriptions are based on whole mounts or dissections only, as the specimens were found to be too poorly preserved for section cutting :—

The eggs are of a yellow colour owing to the contained yolk being of this colour in preserved specimens. Nothing is known regarding the colour of this mass in the living eggs. The eggs are large, measuring about 5.2 mm. in diameter. The egg-membrane, on the surface of attachment, is raised up into small projections (fig. 4) by means of which the eggs are attached to stones or other objects in the nest. Some clusters of from three to five eggs were also found adhering to one another by their sides, and these also showed similar surface projections.

On the following page we have given in a tabular form the sizes of five of the later stages and other details of measurement of various organs, etc., in the respective stages. Other details will be found in the detailed description.

Stage I (fig. 4).—This stage is a fairly advanced one, the contained embryo having already grown to 7.1 mm. in length. The embryo lies within the egg-membrane in a slightly coiled position over the yolk-sac, and shows a continuous fin-fold along the dorsal and ventral surfaces and over the tail, the division into the various portions not being marked off at this stage. The head is differentiated but still attached to the yolk-sac ventrally. The eye and the ear are formed, but the pigment has not been deposited as yet in the eye. Lying posterior to and below the eyes is the heart, its demarcation into chambers has already commenced but has not advanced sufficiently for the various divisions to be identified. The notochord has a straight course in the tail, and is not turned upwards. The mouth opening is seen as a slit and the rudiments of the branchial arches are also present. The tube of the alimentary canal and the liver mass are just distinguishable. The air bladder is present as a small, slightly oval sac. In the body and in the tail region the myocommas of a < shape are present; fifty-seven were counted in a specimen but in the terminal portion of the tail their boundaries could not be seen.

Stage II (figs. 5-6).—This stage is only a little more advanced than the previous one, and but for the lobes of the brain being better marked, the myocommas better developed, the myosepta having a more wavy outline and the eye and the air-bladder being more distinct, there is nothing special to mark in this stage.

Stage of the larvae.	Total length	Maximum depth of the body.	Dimensions of the yolk-sac.	Head length.	Size of the dorsal fin.	Size of the pectoral fin.	Size of the anal fin.	Size of the caudal fin.	Length of the air bladder.	Remarks.
III.	13.8 mm.	1.6 mm.	Diameter 5 mm.	2.1 mm.	...	Just appearing.	6.9 mm.	1 mm.	1.2 mm.	Just hatching out.
IV.	14.2 mm.	1.8 mm.	5.2 × 4.8 mm.	2.5 mm.	...	.8 mm.	7.1 mm.	"	"	Head separated from yolk-sac.
V.	17.1 mm.	2.6 mm.	5.5 × 3.6 mm.	3 mm.	Slightly indicated.	1.5 mm.	11 mm.	1.2 mm.	1.6 mm.	
VI.	18.4 mm.	3.2 mm.	5.2 × 3.1 mm.	3.3 mm.	Undifferentiated, about .8 mm.	1.6 mm.	11.3 mm.	1.4 mm.	2 mm.	
VII.	19.5 mm.	4.1 mm.	...	4.5 mm.	1.5 mm.	2.1 mm.	11.5 mm.	1.9 mm.	4.3 mm.	Last larval stage with no trace of an external yolk-sac.

Stage III.—This is a much more advanced stage than the last one. Some of the larvae have already hatched out while others are still enclosed in the egg-capsule. In hatching, the free posterior portion of the body and the tail (both of which are well developed) are the first to come out of the egg-capsule. The head and the rest of the body, with the large yolk-sac, are then separated out by violent movements of the tail. Some of the larvae show the body still enclosed in the egg-capsule but have the tail protruding.

In this stage only a part of the head is free, the rest is very closely applied along the ventral surface to the yolk-sac, as shown (to some extent) in fig. 7. The mouth is present as a distinct, horizontal slit and the opercular limits are also marked, specially on the ventral surface. The head, which has not developed to any great extent as yet, is broadest in the region of the hind brain. This latter structure is well developed, and shows the large cerebellum getting marked from it. The pectoral fins are just appearing and the continuous dorso-ventral fin has, besides increasing in size, begun to show rudiments of the fin-rays, in the caudal region. The supporting elements of the fin-rays (or pterygiophores) are already well developed. There is nothing particular to note about the sense organs except that the external narial opening is well developed. The gill slits are well advanced and the arches show traces of the development of gill filaments on them. The air-bladder is elongated and sac-like, measuring about 1.2 mm. in length, it shows no constriction.

Stage IV (fig. 8).—The mouth, which was ventral in the last stage, has, owing to the separation of the head from the yolk-sac and the better development of the middle portion, shifted to a position far forward and is now more or less anterior. The head is becoming marked off as a prominent structure owing to the special development of the optic lobes and the cerebellum. The eyes are now partly enclosed in the optic capsules and do not protrude as much as in the last stage. The pectoral fins are better developed and the fin-rays are making their appearance both in the pectoral and in the anal fin-portion of the dorso-ventral fin. The yolk-sac is being gradually absorbed and has become transformed from a rounded to an ovoidal structure. The gill filaments are better developed and even gill-rackers are developing on the arches. The outline of the jaws is also indicated.

Stage V (fig. 9).—This stage, except for showing the beginning of the dorsal fin, is very near the last one. The various organs, however, are better developed and there is a distinct increase in size.

Stage VI.—This stage has still a fairly massive yolk-sac. It shows the operculum quite separated as a flap on either side and forming the posterior limit of the head. The flexure of the brain is better marked, and the medulla oblongata is much better

developed. The eye has become still more enclosed in the capsule. In the skull, the jaws are already nearly complete, the enveloping bones and the teeth are beginning to be laid down. In the vertebral column the body of the vertebrae, the neural and the haemal arches are formed in the anterior part of the body region but not further in the region adjoining the tail. So far as the fins are concerned, this is the first stage in which the fin-rays have begun to make their appearance in the region of the dorsal fin, though the basal pterygiophores could be distinguished in this situation even in the last stage. In the anal and the caudal fins the rays are already quite well developed and the limit between these two fins is also just indicated by the direction of the fin-rays. The alimentary canal, the liver, and the air-bladder are better developed. In the gills, the filaments are larger and are present on all the four gill-arches.

Stage VII (fig. 10).—This is the most advanced stage in the collection and shows no trace of an external yolk-sac. The general colour is milky white in the preserved state. Irregularly scattered chromatophores of the usual shape and of a brownish colour are present on the head and on the abdominal portion; none, however, can be distinguished in the tail region. No scales are developed as yet, but in sections of a portion of the body-wall, scales can be distinctly seen developing in the scale-sacs. There is still a continuous fin-fold, in which the dorsal fin is distinctly marked off about the middle of the animal, and it has well developed fin rays. The thin covering of the fins is still directly in continuation of the original dorso-ventral fin, which latter has become greatly reduced posterior to the dorsal fin but is fairly broad anteriorly. The pectoral fins are much larger and have fully developed fin-rays. The yolk-sac is entirely withdrawn into the body-cavity and is not visible externally. Unfortunately, the condition of the material at our disposal does not allow of a description of the internal yolk sac, as the structure may now be termed. The operculum is quite well developed, its posterior boundary lies a little behind the middle of the distance between the snout and the anus. In the operculum, the opercular, pre-, inter- and sub-opercular elements are marked off, and ossification has commenced. Five branchiostegal rays are already formed and traces of three others can also be seen. The anus lies at a distance of about one-third the total length from the anterior end. The eye is contained about four times in the head length and its distance from the snout is equal to its diameter. The external narial opening, which is seen as a distinct aperture in this stage, is situated near the middle of the distance between the eye and the snout. In the skull region also, ossification has commenced, but the stage is too young to show the various elements. All the jaw-bones are, however, well developed and teeth are present on the maxillaries, dentaries, vomers and palatines. A few can also be seen on the urohyals.

In the body, the irregular myosepta are to be distinguished

only in the middle region. The alimentary canal is very short and shows only the beginning of the stomach and the pyloric caecae. The liver is better developed. The chambers of the heart are becoming more consolidated and the air-bladder is distinctly notched about the middle. The gills are much better developed. The kidneys can be distinguished as faint thickenings, but no genital organs can be satisfactorily identified.

III. THE EGG-CASE OF *CHILOSCYLLIUM GRISEUM*.

(Pl. XIX, fig. 5.)

In 1914, Sundara Raj contributed to the "*Records of the Indian Museum*," Vol. X, pp. 318-319, a note on the breeding habits of *Chiloscyllium griseum*, Müll. and Henle. In his note a description of the egg-case of this dogfish was included. The egg-cases were laid in the marine aquarium at Madras in January 1913. Unfortunately the figure accompanying the note is very poor and, further, is inserted wrong side upwards. Moreover, the egg-cases obtained by one of us differ in certain important characters from those described from Madras. We have, therefore, thought it advisable to give a detailed descriptive account, and a good diagram of the egg-case of this fish. Through the courtesy of Dr. N. Annandale, Director, Zoological Survey of India, we were able to compare our specimens with one of the Madras specimens, now in the collection of the Zoological Survey of India (Indian Museum, Calcutta).

A few words regarding the nomenclature of the Indian species of the genus *Chiloscyllium* would not be out of place here. Day in his "*Fishes of India*," p. 726, pl. clxxxviii, fig. 3 (1878), and later in his "*Fauna of British India, Fishes*," Vol. I, pp. 34-35, fig. 14 (1889), recognized only a single species, viz. *C. indicum* (Gmel.), with *C. griseum*, Müll. and Henle and *C. plagiosum* (Bennet) as synonyms. Tate Regan in his revision of the dogfishes¹ came to the conclusion that the three species are quite distinct. The same view was further confirmed by Garnau² and has also been found by us to be quite sound. Sundara Raj in his paper describes the egg-cases as belonging to *C. griseum* = *C. indicum* of the "*Fauna*" not saying, however, that the two are distinct species. We are indebted to Dr. B. L. Chaudhuri, Assistant Superintendent, Zoological Survey of India, for the confirmation of the identification and for help in working out the synonymy of the species.

The two egg-cases on which the following description is based were obtained in the Gangetic Delta at Port Canning, Bengal, in March 1918, from a gravid female. Each oviduct contained a

¹ *Proc. Zool. Soc. London*, 1908, pp. 347-364, pls. xi-xiii.

² *Mem. Mus. Comp. Zool. Harvard*, XXXVI, p. 66 (1913).

single fully developed egg-case, besides a large quantity of yellowish fluid secretion surrounding a number of eggs.

The egg-cases when fresh were of a light yellowish colour. The specimens preserved in spirit are dark yellow, the margins being still darker, whereas the sides are brownish. It is of a quadrangular shape, much broader in the middle than at the ends. Two of the four sides of this quadrangular structure are very much narrower than the other two, and hence the longer sides, instead of being straight, curve inwards near the two ends, and in a contracted specimen, seem to meet each other. In the middle, the egg-case is much thicker owing to the egg and the yolk contents. Near the upper and lower edges the two surfaces of the chitinous case meet and are united to form a flat surface, which in contracted specimens is wrinkled. The four angles are prolonged into small thin filaments, which, compared with those of the European species of dogfishes, are rudimentary structures, and would be of little use for the attachment of the egg-cases to foreign objects in the sea after these have been laid. But another structure of a different type, and probably more suited to the conditions under which these fishes live, has been developed. Attached to one of the longer sides is a very long (134 mm.) and thick cord of a silky material. Where it joins the egg it broadens out and is attached along a large area on the side. It then gradually tapers to a cylindrical cord. This long cord would be very useful for mooring the egg-cases to any object at the bottom of the sea. A few strands of a white colour also arise from two places on the opposite side.

The two specimens are of the same size, the measurements of one of these are as follows :—

Maximum length	..	..	..	60.8 mm.
„ breadth	..	..	..	31.1 mm.
„ thickness	..	..	..	16.5 mm.

IV. INTRA-UTERINE EMBRYOS.

In this part of the paper we have given descriptions of the intra-uterine embryos of a number of Indian Elasmobranchs. In addition to the material described we had before us a number of embryos as to the specific identification of which we are not certain. These, however, were found to be of great use in elucidating certain general conclusions which are given at the end of this paper.

Scoliodon walbeehmi, Bleeker.

(Pl. XVII, figs. 1, 2, 4, 7 and 8.)

1889. *Carcharias walbeehmi*, Day, *Faun. Brit. Ind., Fishes*, 1, p. 10.

1913. *Scoliodon walbeehmi*, Garman, *Mem. Mus. Comp. Zool. Harvard*, XXXVI, p. 112.

In the young embryo 106 mm. long the head is not at all elongate and the snout much less pointed than in the adult. The

snout measured from the mouth is just equal to the length of the mouth. The mouth is slightly narrowed forwards. The extent of the labial folds which are poorly developed is nearly the same on the two jaws. The distance of the nostrils from the point of the snout is approximately the same as that from the mouth, and the distance between the two nostrils is much less than the length of the mouth. The eyes are large and prominent, much longer than half the length of the mouth and the distance from the nostril or even the width of the gill-opening. The gill-openings are of the same shape as in the adult. The ventrals, second dorsal and the anal fins are of the same type as in fully grown specimens. The pectorals have their outer margin slightly curved and the posterior nearly straight and not at all showing the characteristic appearance of the fins of the adult. The anals in a male embryo of the size noted have stout elongated claspers not reaching the tip of the fins. The caudal fin is broad in the region of the sub-caudal lobe, where there is a distinct notch; a second notch is situated posteriorly at a short distance from the tip.

The placental cord is attached at a point in line with the anterior edge of the pectoral fins and midway between them (fig. 1).

The colour of the specimens preserved in spirit is slightly greyish with traces of brown on the fins.

Measurements :—

Total length	106	mm.
Snout to caudal pits	76.4	mm.
Snout to fifth gill-opening	29.8	mm.
Snout to mouth	10.6	mm.
Length of placental cord	65	mm.

Placental cord.—The nomenclature of the parts, the appendicula and other points about the external structure are dealt with in the general section at the end of this paper. Here we will, however, describe the internal relations with the foetal organs and the histological structure.

The placental cord after entering the body of the embryo is seen to consist of an artery and a vein, the outer wall of the cord is not to be seen inside the body. The artery, which is thinner in diameter, passes through the mesentery and, as shown in fig. 2, joins the dorsal aorta. The venous branch, after a short course, opens into the portal vein.

The placental cord as seen in a transverse section (fig. 7) consists of an artery and a vein surrounded by four main channels, and on the outside surrounded by a wall formed of epithelium two to three cells thick, and having a thin connective tissue lining inside. The wall of the channels mentioned above is also formed of connective tissue. The outer wall of the placental cord is raised into elongated tubular processes, the appendicula; the structure of these is dealt with further on.

Two specimens of embryos of this fish were obtained from an adult shark trawled in Portugal Bay, Ceylon, on the 27th of February, 1911.

***Scoliodon sorrakowah* (Cuv.).**

(Pl. XVII, figs. 6, 9 and 10.)

1889. *Carcharias laicaudatus*, Day, *Faun. Brit. Ind., Fishes*, I, pp. 9, 10, fig. 1.
 1913. *Scoliodon sorrakowah*, Garman, *Mem. Mus. Comp. Zool. Harvard*, XXXVI, p. 110.

In embryos 135 mm. long the head is slightly depressed, the snout is long, gradually narrowing anteriorly and a little rounded at the end. The distance of the snout from the mouth is much longer than the distance between the eye and the first gill-opening. The nostrils are much nearer the mouth than the snout. The mouth is a little wider than long, rounded in front and with feebly developed labial folds on the lower jaw, none on the upper. The teeth are not fully developed.

Fins.—The pectorals are much longer than wide and do not reach the origin of the first dorsal; they have the hind margin nearly straight. The base of the first dorsal is much longer than the distance between the ventral and the anal, and is nearly equal to that between the anal and the caudal; it ends slightly in front of the ventrals. The base of the second dorsal is much less than that of the anal. The caudal is well developed with a large sub-caudal lobe. The claspers in male specimens are feebly developed rods.

The attachment of the placental cord is of the same type as in *S. walbeehmi* described already.

Colour.—The back is of a bluish-grey colour, lighter on the sides and with the ventral surface whitish.

Measurements :—

Total length	..	..	135 mm.
Snout to caudal pits	..	..	72 mm.
Snout to fifth gill-opening	..	..	36 mm.
Snout to mouth	..	..	121 mm.
Length of placental cord	..	..	95 mm.
Yolk-sac placenta	..	..	11.5 mm. × 9 mm.

The above description is based on a well developed specimen out of a large series obtained at Puri, Orissa, during the months of June and August, 1918. There are some younger embryos as well but these do not show any special peculiarities.

***Pristis cuspidatus*, Latham.**

1909. *Pristis cuspidatus*, Annandale, *Mem. Ind. Mus.*, II, pp. 5, 6.

The external characters of the embryos before us, which were collected by one of us from off the coast of Ceylon, have been

dealt with at length by Southwell¹ and later by Hussakof.² The embryos were all presented to the Colombo Museum, Ceylon, and we are indebted to the Director of the Museum for kindly sending two of them to us. We are thus able to add a few notes about the internal anatomy and especially the disposition and connections of the yolk-stalk.

The liver is yellow-ochre in colour and consists of a large undivided right lobe and a much larger left one, which is divided into two. The gall-bladder is small and lies embedded in the left inner lobe of the liver at its upper end; the bile duct after receiving the branches from the liver-lobes opens dorsally into the colon close to its commencement. The stomach is large, of a pale yellowish colour and lies on the left side partly covered by the liver; in the specimen dissected it was found to be quite empty. The duodenum is small and of a bluish-green colour. The colon, which is very large and has a well developed spiral valve, lies on the right side. The contents of the colon were found to be a large quantity of partly digested yolk, which is received from the large internal yolk-sac. The internal yolk-sac lies dorsal to the colon and opens into it close to its commencement. The rectum is bent on itself and has a large pear-shaped gland opening into it dorsally.

The specimen dissected was a female, and had well developed kidneys and oviducts, but only a trace of the ovary was to be seen.

As has been described above there is a large internal yolk-sac connected with the colon internally. This internal yolk-sac is only an enlargement of the end of the yolk-stalk after it enters the body of the embryo, and forms a sort of reservoir for the yolk from the external yolk-sac before its transference into the colon. Unfortunately the external yolk-sac in both the specimens was cut off and so the relations of the blood vessels of the sac and stalk can not be fully described. At the inner end, where the yolk-stalk enters the body of the embryo, a single artery and a vein were seen. The artery passes dorsally and becomes connected with the dorsal aorta, while the vein enters the hepatic portal vein. The other relations are probably the same as are described further on for *Rhinobatis columnae*.

Rhinobatis columnae, Bonaparte.

(Pl. XVIII, figs. 1-6.)

1832-41. *Rh. columnae*, Bonaparte, *Fauna Italica, Pesci*, No. 152, plate.
1909. *Rh. columnae*, Annandale, *op. cit.*, pp. 14-15.

Annandale in the paper cited above has discussed the name, etc., of the Indian species. We have before us two stages of very different ages,—one of a shark-like form and the second in which the embryos resemble the adult in general shape, though still

¹ *Spolia Zeylanica*, VI, pp. 137-139, 1 pl. (1910).

² *Bull. Amer. Mus. Nat. Hist.*, XXXI, pp. 327-330, figs. 1, 2 (1912).

showing certain embryonic characters. We will treat of these stages separately.

I. *Shark-like form* (fig. 1).—We have two specimens of this stage, one a male and the other a female. Unfortunately in both cases nearly the whole of the yolk-cord and the yolk-sac are missing.

The embryos have a large number of branchial filaments coming out of the gill-openings ventrally. The eyes are large and project on the sides of the head; the interorbital distance is much longer proportionately than in the adult. The snout is very small and rounded instead of being pointed as in the adult. The mouth owing to the snout hanging forwards comes to lie in a depression. The spiracles are situated just behind the eyes and have a slightly ovoid outline. The nasal openings have all the valves as in the adult. The branchial region is only slightly inflated. The pectoral fins are attached laterally by a very small base behind the branchial region, but the anterior edge is already growing forwards to unite with the snout to form the disc. The pelvic fins are very small and so are both the dorsal fins. The claspers in the male specimen are merely flat lobes of skin. The tail-fin is not well developed as yet.

There is nothing special to note regarding the internal anatomy of this stage; the various points of interest are dealt with further on in the description of the more advanced specimens.

Measurements of the male specimen:—

Total length	..	..	..	36.5 mm.
Maximum breadth of the pectoral fins	..	..	..	12 mm.
Length of the pectoral fins	..	..	..	9.2 mm.
Distance of the pectoral fins from the snout	..	..	..	7.8 mm.
Snout measured from the mouth	..	..	..	4.2 mm.
Interorbital distance	..	..	..	3.8 mm.
Tail	..	..	..	21.1 mm.

II. *Stage with adult form* (figs. 2, 3).—The snout is not at all pointed and is rather acutely rounded; its length is contained less than six times in the total length; the distance between the outer angles of the nostrils is a little more than half that between the mouth and the end of the snout. The anterior nasal valve is produced far beyond the internal margin of the nostril but does not reach the valve of the opposite side; there is a large valve arising from the outer angle which is connected with a similar valve from the posterior margin. The valve from the posterior margin has in addition a small lobe arising from its inner surface and covered by the anterior nasal valve. The back is slightly arched owing to the large and swollen branchial region. The pectoral fins are evenly rounded and do not possess the straight margin so clearly shown in Bonaparte's excellent figures of the adult (*op. cit*); the breadth across the widest part of the pectoral fins is contained a little more than three times in the total length,

The pelvic fins have a rounded tip and do not show the shape characteristic of the adult. In the male specimens the claspers have developed into small rod-like structures, arising at a point about $\frac{2}{3}$ the length of the fins from the base, and have slightly pointed apices. The pelvic fins are at this stage proportionately much smaller than in the adult; they arise more ventrally and their tips do not reach the base of the first dorsal; the distance between their tips and the base of the first dorsal being a little less than that between it and the second dorsal. The rostral ridges are broadly separated. The back is quite smooth but small tubercles are just indicated along the mid-dorsal line, others are scattered in two rows parallel to the middle and a few are also to be seen round the orbits.

The *mouth* is slightly arched. The teeth are very minute; those along the inner and outer margins of both the jaws are much larger than the others, which are to be seen all over the jaws. The roof of the pharynx also has a large number of small denticles.

The *colour* of specimens in spirit is dark yellowish; the fins are much lighter and appear of a creamy colour; the membrane connecting the snout with the pectoral fins is light yellow; the ventral surface and the yolk-stalk creamy. The yolk-sac, however, is dark yellow.

Measurements of a female specimen :—

Length	..	..	114	mm.
Maximum breadth of the disc			38	mm.
Length of snout measured				
from the mouth	..	..	20.5	mm.
Distance between the nostrils			12.5	mm.
Length of the yolk-stalk	..	..	16	mm.
Yolk-sac	..	..	22	mm. × 28 mm.

Internal anatomy (fig. 4).—We do not propose dealing with the internal anatomy at length; a few of the outstanding features of general interest alone are described. In the pharynx fairly large semilunar openings of the spiracles are to be seen on either side. The oesophagus is small, the stomach is long, having the usual U-shaped form, with well developed longitudinal folds on its inner walls and a thick valve at the pylorus. The duodenum is very short and, like the oesophagus and stomach, quite empty. The colon is very large and has a fully developed spiral valve; the internal yolk-sac opens into it dorsally very near its anterior end on the right side. The colon is full of yolk granules. The rectum is a much thinner tube and has a large rectal gland. In the cloacal region of the rectum the oviducts and ureters also open (fig. 4). The liver and the gall-bladder are fully developed. The former is brownish but the gall-bladder is of the usual greenish tinge. The pancreas and spleen are of a dark yellow colour. The single ovary is as yet poorly developed.

The internal yolk-sac is an ovoidal structure lying slightly

dorsal and to the right of the colon; it is connected with the external yolk-sac through the yolk-stalk and internally with the colon as has been described above.

Histology of the yolk-stalk, etc. (figs. 5, 6).—As seen in a transverse section the yolk-stalk is nearly circular, with a fairly thick wall bounding a spacious internal circular cavity. The thick wall (fig. 6) is formed of:—

(i) A single layer of very flat epithelial cells of epiblastic origin.

(ii) A fairly thick mesoblastic portion, many-layered and with a large number of blood vessels,—both arteries and veins, arranged near the inner periphery in a circle; all the blood vessels are full of blood corpuscles. The cells forming this portion are more or less polygonal with slightly wavy walls and with a small nucleus.

(iii) The innermost hypoblastic layer consisting of a single layer of flat epithelial cells.

The wall of the yolk-sac is also formed of the same three layers, but the mesoblastic portion is not so thick and the hypoblastic layer is indistinguishable in some places.

The blood vessels as ascertained by dissection and serial sections were found to unite with one another, the arteries with arteries and the veins with veins, until, near the point where the yolk-stalk enters the body of the embryo, only a single large artery and a single vein are to be seen. The connections of these blood vessels with those of the embryo are as follows: the artery opens into the dorsal aorta and the vein joins the hepatic portal vein. The exact arrangement of the finer blood vessels on the yolk-sac could not be followed.

The contents of the yolk-sac and the stalk were minute, nearly circular yolk granules.

The arrangement of the blood vessels and the connections of the yolk-sac point to a double mode of absorption of its contents, *viz.* (i) the direct transference of the yolk granules into the colon through the yolk-stalk, and (ii) through the blood vessels.

The above description is based on specimens obtained by dissection from two female specimens trawled at the south end of Periya Paar on the coast of Ceylon, on 23rd of February, 1911. There are nine well preserved specimens besides some in poor condition. The two young shark-like embryos were also obtained from the same locality on the 8th of December, 1910. The disc of the parent fish measured about 2 feet 10 inches in breadth and there was a single embryo in each oviduct.

Trygon kuhlii (Müller and Henle).

(Pl. XIX, fig. 1.)

1909. *Trygon kuhlii*, Annandale, *op. cit.*, pp. 34, 35.

As shown in fig. 1 the outline of the disc of the single female embryo before us is a quite regular curve, not at all angulate.

Anteriorly, owing to the pectoral fins not having grown forwards sufficiently to meet in the middle, there is a very distinct notch on either side separating the fins from the rounded papilla-like tip of the snout. The disc is only slightly longer than broad and the specimen still possesses the original shark-like form, except that the pectoral fins are better developed though not quite lateral in position even yet. The head at this stage is a prominent structure projecting far above the level of the fins, particularly in the region of the fore- and mid-brain. The eyes are large and prominent, hanging outwards. The spiracles are large, broad and more or less semicircular openings, situated one on either side of the head in a lateral rather than a dorsal situation. The other gill-slits, with the large elongated branchial filaments springing out of them, are situated on the ventral surface, but, owing to the thin and transparent skin, can be seen through it from the dorsal surface. The branchial region is only slightly inflated. The number of gill-filaments is very large. Only a few, however, are shown in the figure for the sake of clearness; one of these measured over 50 mm. in length. The skin is quite smooth without any tubercles either on the disc or the tail. The pectoral fins show distinct fin-rays. The tail has a rather thin continuous fin-membrane on the dorsal and ventral surfaces; on the distal half it is better developed on the ventral than on the dorsal side, but there are no fin-rays to be seen. The yolk-sac is rather small and the yolk-stalk has the same structure as has been described in detail for *Rh. columnnae* (p. 229).

The specimen preserved in spirit is of a white colour except for the pectoral fins, which have a brownish tinge. The yolk-stalk is of the same colour as the embryo but the yolk-sac is yellowish. Ventrally the embryo appears brownish owing to the colon shining through it.

Measurements of the female specimen:—

Length of the disc	..	29·1 mm.
Maximum breadth of the disc	..	26 mm.
Interorbital distance	..	5·5 mm.
Snout (measured from the mouth)	..	5·3 mm.
Mouth to vent	..	23·4 mm.
Tail	..	38·2 mm.
Yolk-sac	..	10 mm. by 7 mm.
Yolk-stalk	..	16·5 mm.

Internal anatomy.—The colon is the largest of all the parts of the alimentary canal and lies on the right side; it has the yolk-stalk opening directly into it on the dorsal side, there being no internal yolk-sac. In embryos of *T. bleekeri* the duct, according to Alcock,¹ opens ventrally, but in the specimens of this species and of *T. uarnak* dissected by us it opens dorsally. The duode-

¹ *Ann. Mag. Nat. Hist.* (6), 1X, p. 425 (1892).

num and the stomach both contain large quantities of coagulated material of the nature of a secretion from the uterine glands of the mother and probably absorbed through the large spiracles. The rectal gland, it may be remarked, is a very large elongated sac opening distally into the rectum. The lobes of the liver, of which the left one is the largest, are of a yellow colour. The gall-bladder is a small and thin-walled sac with very little secretion in it. The ovary is not to be distinguished in this stage.

Only a single female specimen of this species was obtained, from a large female trawled at Periya Paar on the coast of Ceylon, on the 7th of February, 1911.

Trygon uarnak (Forskål).

1909. *T. uarnak*, Annandale, *op. cit.*, pp. 22-24, fig. 2.

The embryo is slightly more advanced than that of *T. kuhlii* described above. The disc has assumed a more definite form, the pectoral fins having grown further forwards; otherwise the shape of the disc and head is very similar. The fins-rays also are better developed.

The skin is thicker and a few tubercles along the mid-dorsal line are to be seen. The colour is slightly brownish.

The measurements of the male specimen are as follows:—

Length of disc	25·2 mm.
Breadth of disc	20 mm.
Interorbital distance	5·6 mm.
Snout (measured from the mouth)	5 mm.
Mouth to vent	17·4 mm.
Tail	25 mm.
Yolk-sac	12 mm. by 7 mm.
Yolk-stalk	14 mm.

Branchial filaments.—The specimen has only a few small filaments coming out of the gill-slits ventrally.

We have only a single male specimen before us, though three were obtained from a large female trawled on the 4th of March, 1910, at Portugal Bay, Ceylon.

Hypolophus sephen (Forskål).

(Pl. XIX, fig. 2.)

1916. *Hypolophus sephen*, Chaudhuri, *Mem. Ind. Mus.*, V, pp. 409-410.

Chaudhuri in the paper cited above has given measurements, etc., of two embryos from the Chilka Lake. The specimen before us, also from the Chilka Lake, need not, therefore, be discussed at length; we only mention a few additional facts on the external characters and the internal anatomy.

The embryo is certainly more advanced than those of either of the two species of *Trygon* described above, even though it shows a large number of filaments hanging out of the gill-slits. (The branchial filaments, the yolk-sac and the yolk-stalk are not shown in the dorsal view of this specimen, fig. 2). The pectoral fins have developed further on the two sides, but the papilla of the snout separating them is quite distinct. The pectoral and pelvic fins have well developed fin-rays. The claspers are as yet only flap-shaped structures. The tail has a distinct fold of skin forming a fin-membrane.

The general shape of the body has become more like the rays in that the head does not protrude so much and the body is more depressed to form a flat disc.

Internal anatomy.—The colon is relatively smaller as is also the rectal gland. The stomach and the duodenum both contain a large quantity of coagulated material of the same nature as in *T. kuhlii*. The connection of the yolk-stalk with the colon is also similar.

Pteroplatea poecilura (Shaw).

(Pl. XIX, figs. 3, 3a.)

1909. *Pteroplatea micrura*, Annandale, *op. cit.*, p. 39.

1913. *Pteroplatea poecilura*, Garman, *op. cit.*, pp. 412-413.

As Garman has shown in the paper cited above the name of this Indian species must be *P. poecilura*, the name *P. micrura* being confined to the West Indian form.

In the single embryo (fig. 3) before us, the lines of union of the pectoral fins with the snout are still indicated and the fins have not as yet met in front. The eyes do not protrude so much, the spiracles (fig. 3a) are comparatively smaller than they are in the younger stages figured by Wood-Mason and Alcock,¹ and the appearance of the embryo is more like that of the adult. There are no branchial filaments at this stage and the yolk-sac and the yolk-stalk are already absorbed to a very large extent.

Measurements of a female specimen:—

Length of disc ..	73	mm.
Maximum breadth of disc ..	115	mm.
Interorbital distance ..	14'4	mm.
Snout ..	12	mm.
Mouth to vent ..	51'2	mm.
Tail ..	65	mm.
Yolk-sac ..	6'5	mm. × 4 mm.
Yolk-stalk ..	9	mm.

There is a single specimen of this stage before us. It was dissected out of a large adult specimen trawled in Portugal Bay,

¹ *Proc. Roy. Soc.*, XLIX, p. 359, pls. vii, viii (1891).

Ceylon coast, on 7th November, 1910. There was a single specimen in the right oviduct.

This specimen, though evidently much older than the ones described by Wood Mason and Alcock, has a vestige of a yolk-sac and yolk-stalk, whereas the specimens described by these authors had no trace of a yolk-sac or yolk-stalk (p. 364, *loc. cit.*).

Aetomylaeus nichofii (Schneider).

(Pl. XIX, figs. 4, 4a.)

1909. *Myliobatis nieuhofii*, Annandale, *op. cit.*, p. 51.

1913. *Aetomylaeus nichofii*, Garman, *Mem. Mus. Comp. Zool. Harvard*, XXXVI, p. 436.

1916. *Aetomylaeus nichofii*, Chaudhuri, *op. cit.*, V, p. 413.

This is a very interesting stage in that it is slightly more advanced in the absorption of the yolk-sac and the yolk-stalk than the embryo of *Pteroplatea poecilura* described above.

Only the anterior part of the head can be said to be distinct from the disc (figs. 4, 4a). A horn or tentacle nearly 2 mm. in length projects slightly in front of the spiracles and below the eyes. The rostral fin has a fringe along its posterior margin.

The shape of the spiracles is very characteristic (fig. 4a) and brings into mind the peculiar modification brought about for the large trophonemata from the mother's uterus pouring their secretion into the pharynx. The upper margin of the skin which forms a covering over the spiracles is raised upwards and forwards.

The abdomen is very much swollen ventrally owing to the large colon, which can be seen through the skin. The dorsal fin arises just at the origin of the tail. The claspers in the male specimen are small rod-like structures tapering to a point at their free end; they measure 6 mm. in length.

The body is quite smooth. The yolk-sac and the yolk-stalk have already been very largely absorbed.

The embryos have a brownish colour. In one of them a dark brown line at a little distance from the margin of the disc and closely following its outline is very distinctly to be seen. The long tail has a deep chocolate colour banded with yellowish rings, ventrally its distal portion is entirely yellowish.

Measurements of a male specimen:—

Breadth of the disc	..	111	mm.
Mouth to vent	..	47	mm.
Length of snout	..	8.5	mm.
Rostral fin	..	11	mm. × 7 mm.
Interorbital space	..	16.5	mm.
Size of spiracle	..	13	mm. × 6 mm.
Tail	..	235	mm.
Diameter of yolk-sac	..	1.5	mm.
Yolk-stalk	..	0.4	mm.

Internal anatomy.—The only features worth noting are:—(i) The very large colon with a well-developed spiral valve. The colon measures 21 mm. in length; on being slit open it was found to be filled with yolk granules. Lying dorsal to and opening into the colon is (ii) the large internal yolk-sac. It is connected with the small external yolk-sac through the yolk-stalk. The stomach was quite empty. (iii) The rectal gland is a large structure, (iv) The liver is comparatively small. The specimen dissected was a male and shows the male organs, but not fully developed. Leydig's organ is not quite developed, the vas deferens is also small and not so convoluted.

Two specimens, a male and a female, were obtained from a large fish trawled in Portugal Bay on the 16th of February, 1910.

THE YOLK-STALK AND THE PLACENTAL CORD.

A few remarks about these structures will not be out of place here. In the sharks, as will be shown further on, the placenta is purely of the nature of a yolk-sac placenta, in some more highly evolved than in others. The arrangement and relations of the blood vessels in the yolk-stalk of the Batoids, *e.g.* in *Rhinobatis columnnae*, are of a type essentially similar to that of the sharks. In the more highly advanced or evolved forms of placenta of sharks such as *Scoliodon walbeehmi*, the channel of the yolk-sac is obliterated in the later stages of development, owing to there being no yolk to absorb and the channel in the yolk-stalk being therefore unnecessary, and further owing to the blood vessels having developed to a much greater extent. The yolk-stalk now becomes the placental cord and instead of the channel in the yolk-stalk there is now a large artery and a large vein. The cavities of unknown function lying next to the blood vessels described in the account of the structure of the placental cord of *Scoliodon walbeehmi* may possibly be the remains of the original channel. Another point worthy of note is that the connection between the yolk-stalk and the intestine of the embryo must be stopped before the transformation of the yolk-stalk into the placental cord takes place. As in the earlier stages of the development of the sharks there is a yolk-sac and a yolk-stalk, the stage where there is a direct communication between the yolk-sac and the intestine must exist even in forms that later on have a placental arrangement. Unfortunately we have no material of the very young stages of these sharks at our disposal that would support these theoretical conclusions.

In their descriptions of the embryos, some authors have designated the yolk-stalk of the aplacental Batoids the umbilical cord. This apparently is a misnomer, as in view of what has been stated above, though the yolk-stalk or the stalk of the yolk-sac is transformed in the sharks into the placental cord on the development of the placenta, the converse is never true. In the Batoids with the condition of aplacental viviparity the yolk-stalk has

persisted as such, and not resulted from a retransformation of the placental cord into a yolk-stalk. Further, the condition of aplacental viviparity amongst the Batoids is to be derived directly from that in the oviparous Elasmobranchs and not that in the viviparous forms with a placental development. In fact, there are two distinct lines of development from the oviparous condition. (i) Viviparity with the development of a placenta, (ii) aplacental viviparity. The correct name, therefore, for the structure in these aplacental viviparous Batoids is the yolk-stalk or the stalk of the yolk-sac.

THE APPENDICULA OF SOME OF THE INDIAN CARCHARIDAE.

We have thought it necessary to deal with these structures as a whole in the various species that we have had a chance to examine.

Johannes Müller¹ in his admirable résumé of all that was known up to 1840 regarding the uterine structures, etc. in the Selachians does not mention any such processes in the text, or show any of them in the beautiful figures of the various species at the end of his paper. The species dealt with by him are *Mustelus laevis*, *Mustelus vulgaris* and *Carcharias (Prionodon) sp.* Alcock² is the only author, so far as we know, who has given an account of these structures, and it is to him that we owe the very appropriate name of appendicula. He described these structures for *Zygaena blochii* as follows:—"The placental cords, which were much more delicate, were uniformly covered, except at the extreme foetal end, with flattened, leaf-like, bilobed or trilobed appendicula, from one-eighth to one-quarter of an inch in length, each lobe being one-eighth of an inch broad." For the embryos of the other two species (*viz. Carcharias melanopterus* and *Carcharias dussumieri*), also described in the same paper, no appendicula are mentioned as being present on the placental cord. There are no other references to these structures in the literature consulted.

We have examined the embryos of the following species: *Scoliodon sorrakowah*, *S. palassorah*, *S. walbeehmi* and two other species of *Scoliodon*, the specific identification of which we are not certain, and of a *Cestracion* sp.³ The results of our study of these structures show that there are at least four different types of appendicula in the species studied.

Type (i).—In a single specimen of *Scoliodon* sp. collected from the coast of Ceylon the placental cord is very long, measuring about 19 cm. The placenta is of the usual arborescent type and is attached to a portion of the uterine wall which was preserved along with the embryo. The placental cord is fairly thick, 5 mm. in diameter exclusive of the appendicula; its wall is thrown into

¹ *Abhand. Ak. Wiss. Berlin*, 1840, p. 188.

² *Fourn. As. Soc. Bengal*, LXIX (ii), p. 51 (1890).

³ According to Garman, *loc. cit.*, p. 155, *Cestracion* is the correct generic name for what has until recently been known as *Zygaena*.

folds, which, as shown in pl. xvii, fig. 3, become quite separated here and there to form small flat processes. These processes seem to be the starting point for the formation of the more highly evolved types of appendicula described further on.

Type (ii).—In *Scoliodon walbeehmi* the appendicula are of a more advanced type. As seen with the naked eye the whole surface of the placental cord is raised up into small tubular processes (pl. xvii, fig. 4). The processes or appendicula measure 1·4 mm. in length and 3 mm. to 5 mm. in breadth. The appendicula on being examined with the microscope are seen to be small flattened processes, broad at their free end and gradually narrowing to the point of attachment. Some of them as shown in the figure (where they are shown magnified 25 times) have notches anteriorly in positions where division might have taken place. With the low power of the microscope the wall of the appendiculum, which is formed of many layers of epithelial cells, appears of a much darker colour. There is, however, in the appendicula of this type no vessel of any kind such as that mentioned by Alcock (*loc. cit.*) for *Z. blochii*. Otherwise the appendicula of *Z. blochii* are very near those of this type.

Type (iii).—There are two embryos of a species of *Scoliodon* before us from Madras preserved *in situ* in the uterus of one side. The placenta in this species is of a type intermediate between the simple one found in *S. sorrakowah* and the more highly evolved arborescent one of *S. walbeehmi*. The placental cord, which measures 72 mm. in length, is thickly covered with appendicula. The appendicula as shown in pl. xvii, fig. 5 are elongated, much branched structures; the branches arise from a main axis and the further branching is more or less dichotomous. The appendicula are about 15 mm. in length, but not more than 25 mm. thick. Each of the daughter branches is swollen at its extremity. No vessels can be seen in preparations of this type of appendicula.

Type (iv).—In *S. sorrakowah* and *S. palasorrah* the appendicula are elongated threads, simple or forked at a distance from the point of origin (pl. xvii, fig. 6); they measure up to 60 mm. in length. The appendicula in these two species have the same structures as in the other three types, except that there is a blood vessel in each. The placenta in the forms with this type of appendicula is the least highly evolved, being a true yolk-sac placenta, formed by the processes jutting out from the surface of the yolk-sac and embedding themselves in the uterine wall.

It will be clear from what has been stated, that we can trace a nearly complete series in the evolution of long thread-like single or branching appendicula from mere projections on the wall of the placental cord. It may also be noted here that the appendicula may be present or absent in nearly related species of the same genus; for example, though they were described by Alcock (*loc. cit.*) for *Cestracion blochii*, they are absent on the placental cord of a foetus of another species of *Cestracion*, from the collections of the 'Golden Crown' from the Bay of Bengal. It should

also be borne in mind that though we have a nearly complete series from small projections on the wall of the placental cord to long thread-like appendicula, this does not give us any clue as to the evolution of these structures; nor does it indicate any relationships between the various forms; because in the species with the best-developed appendicula the placenta is of the most primitive and least evolved type and *vice versa*. Indeed, this last-stated fact seems to show that the forms with a less highly organized type of placenta requiring some other mode of absorption of food have developed these additional structures. The appendicula, if this is so, would be more of the nature of acquired or adaptive structures than indications of any genetic relationships.

Histological structure.—As seen in longitudinal sections (pl xvii, fig. 8) the wall of the appendicula is found to be formed of three to four layers of more or less polygonal cells; the core of the finger-shaped processes is filled up by loose connective tissue, which reaches up to the walls of the channels in the placental cord. In the connective tissue portion stellate cells can also be distinguished here and there.

Function.—Alcock, with some doubt, considered the appendicula to be of the nature of lymphatic glands, provided the channels of the placental cord be considered as lymphatics. Their structure and various grades of development, and the blood vessels in the appendicula of *S. palasorrhah* and *S. sorrakowah*, together with the grades of development of the placenta, tend to show that they might, like villi, serve in absorbing the food material secreted by the uterine wall of the mother. This secretion, as was seen in the case of the specimens at Puri, surrounds the embryos completely, just as the amniotic fluid does in the mammals.

PLACENTA.

Having already dealt with the placental cord we will now record a few observations about the placenta in some of the Indian sharks that we have seen, besides adding some notes about the forms previously described.

It may be stated at the outset that the placenta in these forms is of the nature of a yolk-sac placenta. When all the yolk in the yolk-sac has been absorbed, nourishment must be obtained by the embryo from the maternal uterus. This is done in a variety of different ways. In the earlier stages in the aplacental forms the branchial filaments are probably of use in absorbing the nutritious secretions of the uterus in which the embryos are lying. Later on special processes or trophonemata are developed from the uterine wall and these, entering the spiracles of the foetus, pour the nutritious secretion into the alimentary canal of the embryo. In the placental forms the yolk-sac is utilized for the formation of a placenta and the connection of the yolk-stalk with the intestine becomes obliterated; the blood vessels on the other hand become specially enlarged and nourishment is taken to the embryo directly through

the circulation of blood. We have been able to distinguish three distinct grades in the development of the placenta in these forms:—

(i) In *S. sorrakowah* and *S. palasorrah* we have the least modified type of placenta. As shown in pl. xvii, fig. 10, it is the original yolk-sac of the typical rounded to slightly ovoid form. At its lower free extremity it has a number of small protuberances which, as seen in pl. xvii, fig. 9, are embedded in the maternal uterine tissue and form a very simple type of yolk-sac placenta.

(ii) A placenta of a slightly more advanced type is the one mentioned by Müller, *op. cit.*, in his description of the placenta of *Mustelus laevis* and a species of *Carcharias*, where there is a distinct placenta-like interdigitation of folds of the yolk-sac, and these villi-like projections fit into corresponding depressions in the uterine mucous membrane of the mother like the cotyledons of the ruminant placenta.

(iii) In a specimen of *Scoliodon* sp. from Ceylon the yolk-sac has practically disappeared as such, and in its place we find that the placental cord broadens out into a flattened structure showing traces of division and transformation into an arborescent mass. The placenta in the two specimens of *Scoliodon* from Madras is still simpler than this, and is of a character intermediate between that of the second type and the one found in *Scoliodon* from Ceylon. This type when fully evolved is a fairly large arborescent structure formed by the continued subdivision of the distal extremity of the placental cord and the remains of the yolk-sac. The blood vessels in the placental cord also divide again and again to supply the various subdivisions of the placenta, which is a highly vascular structure. The placenta is in close connection with a flat highly vascular portion of the maternal uterine wall. Each embryo is connected by a separate placental connection with a separate part of the uterine wall. This type is found in *Scoliodon walbeehmi* (pl. xvii, fig. 1, shows a side view of only the foetal placental portion with the embryo and the placental cord), and has been shown by Alcock to occur in *Carcharias melanopterus*, *Cestracion blochii* and *Carcharias dussumieri*.

BRANCHIAL FILAMENTS.

In the earlier stages of the intra-uterine embryos of many Batoids large numbers of delicate and much elongated branchial filaments protruding out of the branchial openings of the embryos have been described by many authors. In the course of our studies we also have found these to be present in a number of species from which they had not been recorded previously. These filaments are the greatly elongated gill-processes which issue out of all the branchial slits ventrally except for the spiracles, and are so numerous as to form about one-third of the whole volume

of the embryo in *Pteroplatea micrura*.¹ In the more advanced embryos, however, the branchial clefts are tightly closed and there are no filaments, those which were formerly present having apparently atrophied. These structures, it thus seems, are present only in the earlier stages of the embryonic existence.

The structures have been called by many different names such as branchial or gill-filaments (Wood Mason and Alcock)², external gills or gill-filaments (Wood-Mason and Alcock)³ and trophonematous filaments (Chaudhuri).⁴ The name external gills or gill-filaments suggests that they function as gills and may lead to wrong conclusions being drawn as to their being homologous with or even analogous to the external gills of Amphibia. On the other hand the name trophonematous filaments would lead one to think that they were structures for the absorption of nutriment. But as the name trophonemata has been used by Wood-Mason and Alcock for the "narrow, strap-shaped nourishing processes" of the uterine wall of Batoids, we do not think it desirable that the same or an essentially similar name should be given to processes of the embryo. In our opinion the name branchial filaments is the most suited, as, besides showing their origin, it does not suggest or imply any function for these structures.

The branchial filaments have been already described in the descriptions of the various embryonic forms, their histological structure has been admirably treated by Alcock in his description of the "Embryonic History of *Pteroplatea micrura*" (*Ann. Mag. Nat. Hist.*, Vol. X, pp. 3, 4, 1892), and we have nothing to add to that account.

As to their function, Alcock in the paper cited above considered them to be of use for absorbing the nutriment in the yolk-sac of the embryo. Their very elaborate vascular supply, on the other hand, points to their being of the nature of respiratory structures, possibly in addition to their being of use in the absorption of yolk and the free secretions of the maternal uterine wall.

SUMMARY.

In the general observations we have described certain structures developed by Elasmobranch embryos during different periods of their intra-uterine existence. These structures result in very definite changes in the modes of obtaining nourishment, and may be summed up as follows:—

I. In the *placental* forms, in the earlier embryonic stages, there is no placenta and the yolk-sac functions as such. Later on,

¹ Alcock, *Ann. Mag. Nat. Hist.* (6), X, p. 2 (1892). The correct name of the fish according to Garman as stated previously is *P. poecilura*.

² *Proc. Roy. Soc.*, XLIX, p. 363 (1891).

³ *Proc. Roy. Soc.*, L, p. 204 (1891).

⁴ *Mem. Ind. Mus.*, V, p. 409 (1916).

with the development of the placenta by the modification of the yolk-sac, nourishment is obtained directly from the blood of the mother through the blood-vascular system. In some cases additional structures or appendicula are developed on the placental cord, and these probably absorb the secretion of the uterine wall in which the embryos are floating.

II. In the *aplacental* forms the yolk-sac persists as such through a greater part of the embryonic life and the yolk in it is directly taken into the alimentary canal with or without the intermediation of an internal yolk-sac; possibly, as has been suggested, the branchial filaments also help in its absorption. In the earlier stages, when the branchial filaments are present, these help in the absorption of the secretion of the uterine glands. The blood vessels in the mesoblastic portion of the yolk-sac are also of use in absorbing the nourishment contained within it. During the later stages of development special processes are developed in some cases from the maternal uterine wall and these processes or trophonemta, entering the embryonic spiracles directly, pour the secretion into the pharynx of the embryo. It may also be mentioned here that during the embryonic portion of the life-history the stomach does not function as such, but merely acts as a channel for the transport of food to the colon, where absorption mostly takes place.
